METHOD AND APPARATUS FOR ANCHORING A MINE ROOF BOLT

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BACKGROUND OF THE INVENTION.

1. Field of the Invention

This invention relates generally to an apparatus and method for anchoring devices in rock material. More specifically, it relates to mine roof bolts and methods of using them to support the rock layer exposed in mine roofs by drilling holes in the roofs and mechanically and adhesively anchoring the bolts to higher layers of rock.

2. Description of the Related Art

Mine shafts sometimes experience cave-ins, collapses, or falling rock due to the layered and stratified makeup of the earth. A mine shaft itself may cause fractures and weaknesses in a strata in its ceiling, or it may just expose an inherently weak and unstable layer. To assist in preserving the integrity of the ceiling, it is common to support the ceiling with bolts anchored up into rock layers above the ceiling. Plates between the bolt heads on the exposed ends of the bolts and the ceilings are used to transfer force from the anchored bolts to the exposed layer of the ceiling. In some applications, the exposed end of the anchored bolt is threaded. Onto these bolts, a nut is threaded, and the nut used to place a preload on the bolt to set an initial lifting force to the plates.

Holes, which are slightly oversized to the bolts, are drilled up into the ceiling. Sometimes the holes must be several feet deep to be sure of anchoring the bolts in a stable layer of rock.

Once the holes are drilled, the bolts are inserted into the holes and anchored. There are three methods for anchoring the bolts in the holes, mechanical, adhesive, and mechanically assisted adhesive. This patent relates mostly to the mechanical method or the mechanical aspect of the mechanically assisted adhesive method of anchoring bolts, so the adhesive method will be discussed only briefly before discussing the relevant mechanical art.

Once the hole is drilled, a multi-component adhesive is placed in the blind end of the hole. The components of the adhesive are kept in separate frangible packages to keep them from mixing, for, once they do, a reaction occurs, and the adhesive begins to set up. The components of the adhesive are usually a hardener and a catalyst. When the frangible packages have been placed in the hole, a bolt is inserted and turned rapidly to rupture the packages and thoroughly mix the adhesive components. The adhesive is typically of a fast setting variety and may begin to set after three to five seconds of mixing. For many mechanical anchoring methods, the mechanical anchoring elements on the bolt assist in mixing the adhesive, and the increased resistance to mixing of the setting adhesive activates the mechanical anchoring system.

A very common mechanical anchoring system is shown in U.S. Patent 4,419,805 by Calandra, Jr. This system comprises, basically, a bolt with a threaded end, a camming nut having through its axis a threaded hole to match the bolt, a wooden dowel, and an expansion shell. The camming nut has several sides, the sides being at an angle to the axis of the camming nut to create a wedge effect so that one end of the camming nut is larger than the other. Also, the camming nut has a hole through it transverse to the axis of the camming nut. The diameter of this transverse hole and that of the wooden dowel pin match each other with the length of the dowel pin matching the length of the transverse hole. The expansion shell has at one end a solid

ring. The inner diameter of this ring is slightly larger than the bolt diameter. From this ring, several wedge fingers extend in a direction parallel to the axis of the hole. These fingers are equal in number to the sides of the camming nut and, having a wedge shape, taper as they extend away from the ring.

In operation, the expansion shell is placed over the bolt with the tapered wedge fingers pointing up. The wooden dowel is put through the hole in the camming nut, and the camming nut screwed onto the bolt until the dowel pin stops the bolt from passing any further into the camming nut. The expansion shell is pushed up onto the camming nut with the wedge fingers of the expansion shell aligning with the tapered sides of the camming nut. When an anchor hole has been drilled and filled with the adhesive pouches, the bolt is inserted into the hole and turned rapidly to rupture the pouches and mix the adhesive components. The anchoring components on the bolt serve to mix the adhesive. The rapidly setting adhesive provides resistance to the turning of the anchoring elements until the resistance is great enough to cause the bolt shaft to shear the wooden dowel in the camming nut. Once that occurs, the threads begin to pull the camming nut further onto the bolt and into the wedge fingers of the expansion shell. As the camming nut advances into the expansion shell the wedge fingers are expanded out to wedge in the wall of the anchor hole. The wedging of the expansion shell should stop the turning of the bolt before the adhesive sets. Otherwise, as the adhesive sets, a still turning bolt will cause the adhesive to set as small discrete particles as opposed to a single homogeneous anchor. Once the mechanical anchor is set, the bolt can have a preload placed on it. If a mechanical anchor is not used, an operator must wait until the adhesive sets to preload the bolt. So, while the adhesive provides the strongest anchor, the mechanical anchor makes the bolt system more time efficient and therefore

more economical.

An additional feature in Calandra, Jr. is the use of a washer to contain the adhesive after the frangible pouches are ruptured and the adhesive is mixed. The washer has an inner diameter closely matching the bolt diameter and an outer diameter approximating that of the hole. It is located below the anchor elements at a position that keeps the adhesive contained in a small enough volume that the adhesive essentially fills the volume. The washer may be fixed in position by a press fit on the bolt or it may be welded in place.

Another common type of mechanical anchor used in mine bolts is the bail type anchor. It has a tapered camming nut and tapered wedge fingers like in the previous type, but the tapered wedge fingers are connected to each other at their thinner upper end by a bail. The bail passes up along the outside of the camming nut and across the top of the camming nut at its wider end. A groove in the camming nut allows the bail to stay within the profile of the camming nut, and in most of these bail type anchors, the wedge fingers are not connected by a ring at their thicker end. In this type of anchor, the resistance of the adhesive causes the camming nut, wedge fingers, and bail to turn more slowly than the bolt, so the bolt begins to advance up through the camming nut until it contacts the bail across the top of the camming nut. At that point, the bolt begins to lift the bail off of the top of the camming nut, and the bail then begins to pull the tapered wedge fingers up toward the camming nut. As the tapered wedge fingers and camming nut become more engaged, the wedging effect between the camming nut, tapered wedge fingers, and the hole sides increases. The bail may break once the camming nut and tapered wedge fingers are sufficiently wedged, if the bolt continues to advance through the camming nut. Once the mechanical anchor is set, a preload is placed on the bolt. Subsequently, the resin fully sets.

Many inventions in this field are directed to additional means for mixing the adhesive as well as the anchoring mechanism. U.S. Patent 4,516,886 by Wright features a bail type anchor that has a two part bail to improve the mixing of the adhesive components. In addition to the bail that passes directly over the camming nut, a second bail extends above the camming nut, effectively providing an elongated hoop to puncture the component pouches and mix the adhesive. The bail that runs directly across the top of the camming nut has a hole through it slightly smaller than the bolt hole in the camming nut. The resistance of the adhesive causes the bolt to force its way through the first bail and advance through the camming nut until the bolt reaches the extended bail which begins to pull the tapered wedge fingers into wedging action with the camming nut and hole sides. Other patents add different mixing means. U.S. Patent 5,042,961, by Scott, fixes a helix shaped length of wire to the bolt below the wedging mechanism, while U.S. Patent 5,073,065, by Kleineke, places an adhesive mixing and retention washer on a tapered shoulder below the anchoring mechanism.

The use of the setting adhesive to drive the wedging action of the mechanical portion of the various anchoring systems has severe drawbacks. Obtaining complete mechanical engagement before the adhesive sets is very time dependent. Variations in the mechanical components, in particular, may prove problematic. The strength of wood shear pins may vary widely. If a sheer pin does not break and the expansion shell is still churning as the adhesive sets, the adhesive may set as small disassociated particles as previously discussed. Once that occurs, the resulting adhesive gravel may provide enough resistance to activate the mechanical anchor, and the bolt may anchor mechanically. However, the adhesive anchor is lost and it is the adhesive anchor that provides the majority of the long term strength of the anchoring system.

This is particularly dangerous since the bolt appears to be anchored, but the superior long term anchor of the adhesive component has been lost. Because of the appearance of a good anchor, remedial measures such as placing another bolt immediately nearby are not undertaken. The resulting weakly anchored roof bolt is often called a "spinner" in the mining industry.

Occasionally, if it is obvious to an operator that a mechanical anchor is not actuating, the operator may pause long enough for the resin to nearly set, and then resume turning the bolt. This brings about the destruction of the adhesive, but will pull the bolt up tight for a preload and will give the appearance of a successful anchoring. However, the actual result is a "spinner".

Some types of rock are particularly soft. This, too, is a problem. The mechanical anchor may widen the hole as it turns and fail to pull tight within the hole. If it continues to turn in a loosened hole, again, the adhesive is at risk.

Another problem is more specific to the mechanical elements of the anchoring systems that use expansion shells having the tapered wedge fingers joined by a common ring at the base with a camming nut being drawn into the expansion shell. These systems typically have four sides on the camming nut and four tapered wedge fingers on the expansion shell with each tapered wedge finger being driven out to the hole wall by a corresponding camming nut side. Sometimes the camming nut will turn within the expansion shell, twisting the wedge fingers to an angle about the axis of the bolt and preventing an effective anchoring in the hole. Again, this substantially decreases the overall holding power of the bolt, allowing ceiling collapses where the load exceeds the strength of the anchor.

SUMMARY OF THE INVENTION

The present invention is an improved mine roof bolt having a main bolt shaft with a

threaded end, a fixed camming nut, and threaded expansion shell. It has a more easily activated mechanical anchor and an overall simpler design than the prior art.

Accordingly, it is a primary objective of this invention to improve mine safety by decreasing the rate of occurrence of "spinners" in mine roof bolts.

It is a further objective of this invention to provide a mine roof bolt with a mechanical anchoring system that is not dependent on a setting adhesive for activation.

It is also an objective of this invention to provide a mine roof bolt that is easier to anchor in a receiving bolt hole.

It is a another objective of this invention to provide a mine roof bolt that has fewer moving parts in the mechanical anchoring system.

It is a still further objective to provide a mine roof bolt which decreases the occurrence of twisting of the expansion shell.

It is yet another objective of this invention to provide a mine roof bolt system that does not use a shear pin such as the wooden dowel discussed above in the relevant art.

It is still yet another objective of this invention to provide a mine roof bolt that can be used without an adhesive altogether.

It is still yet a further objective of this invention to provide a mine roof bolt having a built in timer function.

As discussed above, the article of the present invention overcomes the disadvantages inherent in prior art methods and prior art devices for anchoring a mine roof bolt. In this respect, before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and/or to the

arrangement of the support structure set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced and carried out in various and diverse ways. Also, it is to be understood that the phraseology and terminology employed herein are for the purposes of description and should not be regarded as limiting.

Accordingly, those skilled in the art will appreciate that the concept upon which this invention is based may readily be utilized as a basis for the design of other structures, methods, and systems for carrying out the purposes of the present invention. It is important, therefore, that the claims be regarded as including such equivalent constructions insofar as they do not depart from the spirit and scope of the present invention.

Furthermore, the purpose of the foregoing Abstract is to enable the U.S. Patent and Trademark Office and the public generally, and especially including the practitioners of the art who are not familiar with patent or legal terms or phraseology, to determine quickly from a cursory inspection, the nature and essence of the technical disclosure of the application. The Abstract is neither intended to define the invention of the application, nor is it intended to be limiting to the scope of the invention in any respect.

BRIEF DESCRIPTION OF THE DRAWINGS

Additional utility and features of this invention will become more fully apparent to those skilled in the art by reference to the following drawings, wherein all components are designated by like numerals and described more specifically.

Fig. 1 is an isometric view of the bolt portion of the instant invention.

Fig. 2 is an isometric view of the expansion shell portion of the instant invention.

Fig. 3 is an isometric view of the bolt portion and expansion shell portion assembled.

Fig. 4 is an enlarged isometric view of the working parts of the instant invention.

Fig. 5 shows a mine roof bolt of the instant invention anchored in a hole.

Fig. 6 shows an example of the current art wherein the camming nut moves along the lengthwise direction of the threaded section.

Fig. 7 shows an embodiment of the instant invention wherein the expansion shell moves along the lengthwise direction of the threaded section.

Fig. 8 shows an embodiment of the instant invention wherein the expansion shell has bails extending from it with wedges on each bail, which expansion shell moves along the lengthwise direction of the threaded section.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

The following discussion illustrates only some of the possible configurations claimed in this invention and should not be interpreted as limiting the scope of the claims. Fig. 1 depicts the bolt portion (10) of the mechanical anchoring system. The bolt has a means for turning it (20) via a driver or wrench on one end, machine threads (30) on the other end, and a camming nut (40) fixed on the shaft of the bolt (10) at a position nearer to the machine threads (30). Fig. 2 shows an expansion shell (50) having as its central component a threaded nut portion (60), and at least two, in this case two, wedge fingers (70) extending from the threaded nut portion (60) in a direction essentially parallel to the axis of the hole through the threaded nut portion (60). Fig. 3 shows the expansion shell (50) threaded onto the machine threads (30) of the bolt portion (10) with the wedge fingers (70) directed towards the camming nut (40).

To use the bolt assembly (80), it is inserted into a drilled hole in the roof of a mine shaft until the load bearing plate contacts the mine roof. The bolt (10) is turned while the expansion

shell (50) is kept from rotating, either by contact of the wedge fingers (70) with the sides of the hole or by a setting adhesive, which has previously been placed in the hole and is mixed by the expansion shell and bolt. This pulls the expansion shell (50) along the machine threads (30) of the bolt (10) towards the conical camming nut (40). As this continues, the wedge fingers (70) of the expansion shell (50) are driven out into contact with the hole sides by the camming nut (40). Once the resistance between the hole sides and the wedge fingers (70) is greater than the resistance between the wedge fingers (70) and the camming nut (40), the bolt assembly (10) will be pulled into the hole more than the expansion shell (50) will be pulled along the bolt (10). This may occur relatively quickly if the wedge fingers (70) are so shaped that the ends anchor into the sides of the wall without being spread by the camming nut (40).

As has been discussed, an adhesive is frequently used in the anchoring process. The adhesive is contained in pouches which are placed in the hole before the bolt is inserted. Because the expansion shell (50) may be placed at the leading end of the threaded section (30) of the bolt portion (10), it may be necessary to shape the threaded nut portion (60) of the expansion shell (50) in such a way that the adhesive can flow past it when the mechanical anchor is inserted into the hole. As one example, if the expansion shell (50) has two wedging fingers (70), the threaded nut portion (60) can have a flattened shape wherein the wedge fingers (70) attach at the narrower sides. The flattened shape would create greater clearance between the threaded nut portion (60) and the sides of the hole, allowing adhesive to flow past the threaded nut portion (60) as the mechanical anchoring system is inserted into the hole. As another example, if an expansion shell (50) has three wedge fingers (70) attached to it, the threaded nut portion (60) could have a clover leaf shape wherein the wedge fingers (70) attach at the lobes of the clover

leaf and the adhesive could flow past the threaded nut portion (60) through the interstices, or notches, between the lobes. Configurations with additional wedge fingers (70) would require other, perhaps similar, shapes.

The camming nut (40) may be fixed in its linear position in various ways and may also vary in its shape. If it is round, like a cone, it can have a rotational motion relative to the wedge fingers (70) and may be fixed to the shaft of the bolt portion (10) of the mechanical anchoring system. One means of doing this is to have machine threads internal to the camming nut (40) which match those of the machine threads (30) of the bolt portion(10). The camming nut (40) can then be screwed down to where the machine threads (30) end, thus fixing the linear and angular location of the camming nut (40). Other means of so fixing the camming nut (40) include crimping the camming nut (40) onto the bolt portion (10) of the mechanical anchoring system or welding the camming nut (40) to the bolt portion (10). If the bolt portion (10) has a larger diameter tapering down to a smaller diameter for the machine threads (30), then the camming nut (40) may be linearly located merely by it having an inner diameter sized between that of the machine threads (30) and the bolt portion (10) and being slid over the machine threads (30) to the taper section.

If it is desired that the camming nut (10) not have any rotational motion with respect to the expansion shell (50), it may be held in its linear location by a support washer and allowed to spin on the bolt portion (10). This is particularly desirable if the camming nut (10) is not round like a cone but instead has flat sides tapering from a large end to a smaller end to engage the wedge fingers (70). Such a support washer could be fixed in its linear position in many of the ways already discussed for the camming nut (40) such as internal threads, crimping or press

fitting, welding, and a tapered shaft section.

Fig. 8 shows an embodiment wherein the threaded nut portion of the expansion shell moves away from the linearly fixed camming nut as opposed to toward the camming nut. The wedge fingers are reduced to much thinner dimensions for most of their length with their ends expanding to wedge shapes that engage a camming nut which tapers away from the threaded nut portion. The wedge fingers may be reduced down to where they are essentially bails having the needed tensile strength to pull the wedge sections into engagement with the camming nut. Turning the bolt causes the threaded nut portion to move away from the camming nut, pulling the wedge sections into engagement with the camming nut, wedging the mechanical anchoring system into the sides of the hole. The camming nut may be rotationally fixed or it may be allowed to turn freely and held in linear location by a support washer. It may have a conical shape or flat sides.

In one embodiment, the quantity of machine threads (30) between the threaded nut portion (60) of the expansion shell (50) and the camming nut (40) serve as a timer. The combination of a driver operating at a typical speed with the selected quantity of machine threads (30) results in the expansion shell (50) traveling the needed distance in a predetermined amount of time.